1. OPENING REMARKS

By Robert W. Boswinkle, Jr.

NASA Langley Research Center

NASA ACOUSTICS RESEARCH

The NASA noise research program goes back many years, some 40 years at the Langley Research Center, and is very broad in scope. It includes fundamentals of noise generation and propagation from aircraft components, structural response, the effects of noise on people, and sonic boom. In regard to reducing aircraft engine noise, it includes at least three approaches: reduction of noise generation, absorption of generated noise, and modification of the aircraft flight operational procedure. The second approach, absorption of generated noise, is the one that was pursued in the program which is the subject of this present conference.

These NASA research efforts are part of an integrated national program. NASA has associations with many organizations in coordinating and conducting acoustics research. These associations extend throughout industry, the universities, the professional societies, and the government. For example, the Aircraft Noise Abatement Program, under the chairmanship of the Department of Transportation, has representation of all applicable Government agencies and is the cognizant coordinating body for work such as is to be discussed at this conference.

NASA CONFERENCES

One way of reporting the results of NASA research is through technical conferences. In 1968, for example, the first NASA conference devoted exclusively to noise research was held. The $2\frac{1}{2}$-day conference was entitled "Progress of NASA Research Relating to Noise Alleviation of Large Subsonic Jet Aircraft." Various NASA Centers and their contractors presented papers in sessions entitled Nacelle Acoustic Treatment Technology, Nacelle Acoustic Treatment Application, Noise Generation and Reduction at the Source, Operational and Environmental Considerations, and Subjective Reaction.

The acoustic treatment and application sessions of the 1968 conference dealt largely with the early results of the NASA Acoustically Treated Nacelle Program. In this effort two companies under contract to NASA, McDonnell Douglas and Boeing, studied means of minimizing the radiation of fan noise from turbofan engines. The contracts are nearly completed now and most of the final results will be presented in the present conference.

DOCUMENTATION

It may be helpful to describe the various reports, other than those included in the present compilation, that have come about as a result of the McDonnell Douglas and Boeing studies. At the present time, the best source of the technology of nacelle acoustic treatment is included in the compilation of the papers presented at last year's conference (ref. 1).

The following reports are in preparation by the two contractors. These reports will present a final account of the studies and are much more detailed than reference 1 or the present compilation.

The McDonnell Douglas final report is entitled "Investigation of DC-8 Nacelle Modifications to Reduce Fan-Compressor Noise in Airport Communities" and includes

Part I Summary of Program Results
Part II Design Studies and Duct-Lining Investigations
Part III Static Tests of Noise Suppressor Configurations
Part IV Flight Acoustical and Performance Evaluations
Part V Economic Implications of Retrofit
Part VI Psycho-Acoustical Evaluation

The Boeing final report is entitled "Study and Development of Turbofan Nacelle Modifications to Minimize Fan-Compressor Noise Radiation" and includes

Volume I Program Summary
Volume II Acoustic Lining Development
Volume III Concept Studies and Ground Tests
Volume IV Flightworthy Nacelle Development
Volume V Sonic Inlet Development
Volume VI Economic Studies
Volume VII Subjective Evaluation of Treated Nacelle Noise Reduction

Reference 2 is a recent report which was prepared as part of the Nacelle Acoustic Treatment Program. The work was done by Pratt and Whitney Division of United Aircraft Corporation under NASA contract NAS 1-7129. It deals with noise attenuation in acoustically treated ducts.

One other group of documents is of interest. As part of the contractual arrangement with McDonnell Douglas and Boeing, the two companies agreed to make available to NASA, for distribution to industry, the results of all of their previous work pertaining to aircraft noise alleviation. The documents were reviewed by NASA and those considered of interest to others, some 44 of them, were announced in reference 3. Abstracts of the

documents, copied from reference 3, are included herein as an appendix. These documents may be obtained from:

Clearinghouse for Federal Scientific and Technical Information (CFSTI)
Springfield, Virginia 22151

The availability of these documents in hard copy form (HC), at a cost of $3.00 apiece, or in microfiche (MC), at a cost of $0.65 apiece, is indicated for each report. Additional documents from the two companies are being reviewed and will be announced in future issues of "Scientific and Technical Aerospace Reports" (STAR), which is an NASA abstract journal available in many technical libraries. References 1 and 2 are also available from CFSTI.

REFERENCES

1. Anon.: Progress of NASA Research Relating to Noise Alleviation of Large Subsonic Jet Aircraft. NASA SP-189, Conference held at Langley Research Center, Oct. 8-10, 1968.

2. Feder, Ernest; and Dean, Lee Wallace III: Analytical and Experimental Studies for Predicting Noise Attenuation in Acoustically Treated Ducts for Turbofan Engines. NASA CR-1373, 1969.

3. Scientific and Technical Aerospace Reports, Vol. 6, No. 20, Oct. 23, 1968, pp. 3395-3401.

APPENDIX

McDonnell Douglas and Boeing Reports

pertaining to

Aircraft Noise Alleviation

Copied from Oct. 23, 1968 (vol. 6, no. 20) issue of

Scientific and Technical Aerospace Reports

(STAR)

02 AIRCRAFT

Includes fixed-wing airplanes, helicopters, gliders, balloons, ornithopters, etc; and specific types of complete aircraft (e.g., ground effect machines, STOL, and VTOL); flight tests; operating problems (e.g., sonic boom); safety and safety devices; economics; and stability and control. For basic research see: 01 Aerodynamics. For related information see also: 31 Space Vehicles; and 32 Structural Mechanics.

N68-32190# Boeing Co., Renton, Wash. Commercial Airplane Div.

THE REDUCTION OF FAN NOISE IN TURBO-FAN ENGINES BY USE OF ACOUSTICAL LININGS. VOLUME 1: SUMMARY OF THEORETICAL AND EXPERIMENTAL DATA

A. O. Andersson, A. J. Bohn, and R. A. Mangiarotty 24 Oct. 1967 111 p refs Previously X68-18469
(D6-17100, V. 1) CFSTI: $3.00

Initial results and conclusions are presented on a program to develop theoretical methods and experimental techniques leading to a better understanding of the technology for acoustical treatment of engine fan ducts. Theoretical prediction methods are being used for lining optimization studies, and sufficient experimental data have been acquired to compile acoustical design criteria for treating engine fan ducts. Some correlation has been obtained between laboratory flow duct and full scale engine duct acoustical performance. Existing acoustical materials are being evaluated, and an analog computer technique has been developed for determining the desirable characteristics of lining materials. A new nonmetallic lining material, polyimide resin glass fiber, is being developed and some evaluation has been completed. Author

N68-32191# Boeing Co., Renton, Wash. Commerical Airplane Div.

THE REDUCTION OF FAN NOISE IN TURBO-FAN ENGINES BY USE OF ACOUSTICAL LININGS. VOLUME 2: DETAILED THEORETICAL AND EXPERIMENTAL DATA

A. O. Andersson, A. J. Bohn, and R. A. Mangiarotty 24 Oct. 1967 152 p refs Previously X68-18452
(D6-17100, V. 2) CFSTI: HC $3.00/MF $0.65

This volume consists of the appendices to N68-32190. The data presented were analyzed and reduced from the bulk of the test data in the experiments and theoretical analyses. Author

N68-32192# Boeing Co., Renton, Wash. Commercial Airplane Div.

ACOUSTIC AND THRUST CHARACTERISTICS OF THE SUBSONIC JET EFFLUX FROM MODEL SCALE SOUND SUPPRESSORS. PART 1: UNHEATED JETS, VOLUME 2

R. A. Mangiarott and D. Elizabeth Cuadra 27 Dec. 1967 141 p refs
(D6-15071, V. 2) CFSTI: $3.00

Acoustic near and far field data and thrust characteristics are presented for four model nozzle configurations. A smooth-walled conical nozzle serves as a reference model; comparison models include a rough-walled conical nozzle, the Boeing 21-tube suppressor nozzle, and a 12-fluted nozzle. Using unheated air, these nominally tenth-scale (6 square-inch exit area) nozzles were tested for their noise generation characteristics for exit Mach numbers $0.5 < M_j < 0.9$ and for their thrust characteristics for exit Mach numbers $0.2 < M_j < 0.8$. (See Volume 1, N68-32196.) Author

N68-32193# Boeing Co., Renton, Wash. Airplane Div.

INTERIM PREDICTION METHOD FOR THE ACOUSTIC FAR FIELD OF EJECTORS

D. Elizabeth Cuadra 2 Aug. 1966 39 p refs
(D6-17093TN)

A far field acoustic prediction method is recommended for the broadband jet noise of ejectors for the cases of fully mixed flows and unmixed flows, together with shroud length criteria for complete mixing. The beginning of a method for partially mixed flows is also indicated, but additional knowledge, on both mean flow properties and turbulence properties is needed to make it workable. Author

N68-32194# Boeing Co., Renton, Wash. Airplane Div.

LIMITED COMPRESSOR NOISE SURVEY: ANALYSIS OF TEST RESULTS

J. A. Crim and R. E. Russell 25 May 1966 48 p refs
(D6-11226TN) CFSTI: HC $3.00/MF $0.65

An exploratory research program was carried out to investigate possible causes of fan and compressor noise. Several ideas had been advanced with respect to the source of this noise. The experiments, carried out on a 5.3-inch diameter fan, were aimed at quickly testing these theories, and at finding promising methods of reducing the noise. The results are not quantitatively applicable to a full size fan. However, there is reason to believe that the qualitative trends will be present in larger fans. The following five basic areas of noise generation were investigated: (1) upstream turbulence, (2) rotor tip flow field, (3) rotor loading (4) rotor/inlet guide vane spacing, and (5) inlet guide wave treatment. The two most promising means of reducing fan noise are rotor unloading and injecting air out the trailing edge of the inlet guide vanes. Author

N68-32195# Boeing Co., Renton, Wash. Airplane Div.

INTERNAL SUPPRESSION OF COMPRESSOR NOISE OF THE JT3D-3B ENGINE WITH 3/4 LENGTH FAN DUCTS

A. J. Bohn 6 May 1966 63 p Revised
(T6-3498, Rev. A) CFSTI: $3.00

Acoustic treatment of internal surfaces of the inlet and 3/4 length fan ducts of the JT3D-3B engine were tested. Effects of variations in treatment design, length of treated section, areas of treatment and depth of backing space within the fan ducts were studied. The treatment design tested in the inlet duct had no measurable effect on engine noise. Treated 3/4 length fan ducts reduced peak flyover noise (calculated for 200 foot altitude) by from one PNdb at 4000 lbs static thrust up to 7 PMdb at 15,000 lbs static thrust, and by 4 PNdb at maximum static thrusts. The effectiveness of a unit area of treatment in the fan duct varied nonuniformly with its location within the duct. Consequently, no reliable measure of attenuation in terms of a nondimensional ratio such as L/d (length of treatment over depth or diameter of duct) could be deduced for application to other engines. Author

N68-32196# Boeing Co., Renton, Wash. Airplane Div.

VELOCITY AND SHEAR PROFILES IN THE SUBSONIC JET EFFLUX FROM MODEL SCALE SOUND SUPPRESSORS. PART 1: UNHEATED JETS, VOLUME 1

James A. Ranner and D. Elizabeth Cuadra 14 Mar. 1966 111 p refs
(D6-15071, V. 1) CFSTI: $3.00

Mean velocity and shear patterns throughout the major noise generating regions of the jet efflux from four nozzle configurations are described. A smooth-walled conical nozzle serves as a reference model; comparison models include a rough-walled conical nozzle, the Boeing 21-tube suppressor nozzle, and a slotted nozzle based on the Rolls-Royce suppressor. Using unheated air, these nominally tenth scale (6 square-inch exit area) nozzles were tested for exit Mach numbers ranging from 0.1 to 1.75. Implications regarding the sound generation are discussed. (See Volume 2, N68-32192.) Author

N68-32197# Boeing Co., Renton, Wash. Airplane Div.
PNDB GROUND CONTOUR DETERMINATION FOR JET AIRCRAFT
J. V. O'Keefe 18 Mar. 1966 37 p refs Revised
(D6-15082TN, Rev. A) CFSTI: $3.00

Procedures are outlined for determining maximum jet noise levels for ground static and flight conditions. A method for defining ground contour iso-PNdB lines for a specific engine airplane match and an assigned flight profile is provided. Jet noise level predictions are in terms of full octave band sound pressure levels of ground-to-ground sideline noise or air-to-ground sideline or fly-over noise. These values may be converted to overall sound pressure levels (OA-SPL) or a subjective rating of perceived noise levels (PNdB). Author

N68-32198# Boeing Co., Renton, Wash. Airplane Div.
PROCEDURES FOR JET NOISE PREDICTION
M. B. Mc Kaig, R. H. Sawhill, and John B. Large 11 Mar. 1965 29 p refs Revised
(D6-2357TN, Rev. A) CFSTI: $3.00

Calculation procedures are provided for predicting maximum flyby noise from jet aircraft exhausts. Three types of engine exhausts are considered: turbojet with standard circular nozzle; turbojet with nonstandard nozzle; and turbofan or bypass engine with unmixed exhausts or completely mixed exhausts. Noise predictions are in terms of octave-band sound pressure levels of maximum air-to-ground flyby noise or of maximum ground-to-ground sideline noise. These levels may be converted to an overall sound pressure level or to a subjective rating such as perceived noise level. Author

N68-32199# Boeing Co., Renton, Wash. Airplane Div.
FAN-DISCHARGE NOISE SUPPRESSOR TEST JT8D ENGINE
M. B. Mc Kaig 28 Oct. 1964 47 p
(T6-3166) CFSTI: $3.00

To determine if suppression of fan-discharge noise is feasible in the high-velocity duct system of a turbofan engine, an acoustically treated extension of the fan discharge duct of a JT8D engine was tested. Engine thrusts ranged from 4000 to 13,500 pounds (maximum static). More than 20 db attenuation of discrete-frequency spike noise was obtained. White noise between spikes also was reduced as much as 8 db. It is concluded that acoustic lining in high-velocity air ducts can give useful amounts of attenuation, and that application of the technique to turbofan engines is promising because of the large proportion of high-frequency noise discharged from the fan duct. Author

N68-32200# Boeing Co., Renton, Wash. Transport Div.
J-75 INLET NOISE SUPPRESSION TEST
M. B. Mc Kaig 27 Oct. 1964 60 p
(T6-3173) CFSTI: $3.00

Three devices were tested on a J-75 turbojet engine for reducing compressor or fan noise radiated from the inlet: (1) sonic throat, (2) absorbent inlet lining, and (3) absorbent inlet guide vanes. The basic inlet design simulated a supersonic inlet with expandable spike. The first device, the sonic throat, was formed by setting the spike in its fully expanded, supersonic-cruise position, and then advancing the throttle until choking occurred. The absorbent inlet lining consisted of acoustic material extending along the inside of the barrel for a length of about one diameter. The absorbent guide vanes, 20 in number, were placed directly upstream of the engine's fixed inlet guide vanes. The most effective single device was the choked inlet, delivering 10 to 15 PNdB. Conflicting results were obtained as to the relative merits of the inlet lining and inlet guide vanes, but they were probably about equally effective, giving around 3 PNdB. Author

N68-32201# Boeing Co., Renton, Wash. Airplane Div.
ATTENUATION OF AUXILIARY POWER UNIT (APU) EXHAUST NOISE BY STACK INSERT DEVICES
V. E. Callaway 12 Aug. 1964 18 p
(T6-3160) CFSTI: HC $3.00/MF $0.65

Attenuation of 727 auxiliary power unit exhaust noise provided by stack insert devices are presented. The combination of an in-line flow-through muffler and an exhaust deflector was found to be the most effective method of reducing this noise. These two devices complement each other in their attenuation properties; the deflector devices reduce levels in frequencies below 300 cps by 2 to 7 dB, while the muffler reduces speech interference level frequencies (600 4800 cps) by 4 to 8 dB. Author

N68-32202# Boeing Co., Renton, Wash. Airplane Div.
AIRCRAFT ACOUSTICS: COMMUNITY NOISE PREDICTION
K. Fukushima 2 Jul. 1964 70 p refs
(D6-4219TN) CFSTI: $3.00

A computer program was written specifically to determine the following: (1) The community noise level expected at an airport, given the take-off (normal and power cutback) or landing path of the aircraft, its engine noise level and parameter governing attenuation of the radiated engine noise. (2) The geographical plot of ground noise level, varying time, the point of the aircraft's break release and the chosen flight path. Author

N68-32203# Boeing Co., Renton, Wash. Transport Div.
COMMUNITY NOISE LEVELS FOR VARIOUS AIRCRAFT DURING TAKE-OFF AND LANDING
R. D. Hulsey 5 Feb. 1964 21 p refs
(D6-9375TN) CFSTI: $3.00

Data from many sources were gathered and processed to obtain noise as a function of altitude for the take-off and landing approaches of various airplanes. The purpose here is to present, in one central document, material that can be used for aircraft noise comparisons at a later date and thus eliminate the confusion that usually arises from multiple sources of information. Author

N68-32204# Boeing Co., Renton, Wash. Transport Div.
PROCEDURE FOR ANALYZING DATA FROM UNCONTROLLED FLY-BY TESTS
M. B. McKaig 1 Oct. 1963 37 p
(D6-9815TN) CFSTI: $3.00

Analysis of acoustic data from fly-by tests offers special difficulties when the basic flight conditions are uncontrolled; from test to test there may be variations of speed, altitude, flight path, and weather conditions. The effects of these variables on the recorded sound may make direct comparison of results very misleading. A procedure is set forth for reducing these effects, by referring recorded sounds to the airplane's orientation with respect to the observer at the time the sounds originated; the sound levels are then corrected to standard conditions of distance and weather. Author

N68-32205# Boeing Co., Renton, Wash. Transport Div.
GRAPHICAL DETERMINATION OF COMMUNITY-NOISE CONTOUR COORDINATES
Merle B. McKaig 28 Jun. 1963 28 p
(D6-9582TN) CFSTI: $3.00

A graphical method is presented for determining the location in a community of the peak-noise contour lines expected from operation of a given type of aircraft from a nearby airport. Two variations of the method are included: how to show the effects of

cut-back, and how to determine the peak level to be expected at a given ground location. Steps in the presentation are given in enough detail that users of the method need not have extensive technical training. Author

N68-32206# Boeing Co., Renton, Wash. Transport Div.
THE DESIGN AND CONSTRUCTION OF AN ANNOYANCE SCALE FOR JET ENGINE NOISE
Stanley J. Rule 23 Jan. 1963 62 p refs
(D6-4348) CFSTI: $3.00

A research program is described on the development of a human reaction scale for airplane noise. Such a scale is useful in determining the relative effects of noise reduction procedures on human comfort. The annoyance scale has been found to be applicable in the SPL range 60 to 100 db to broadband noises which do not contain discrete components. A scaling relationship has been developed which permits an annoyance equivalence to be established between broadband noise and impulse noise. Author

N68-32207# General Applied Science Labs., Inc., Westbury, N. Y.
INLET NOISE
Simon Slutsky Renton, Wash. Boeing Co. 25 Oct. 1962 55 p Prepared for Boeing Co., Renton, Wash.
(D6-4241) CFSTI: $3.00

Three mechanisms have been found to be of importance in inlet attenuation or transmission. The first involves the phenomenon of wave propagation cut-off frequencies experienced by spiral progressive waves below which rapid attenuation occurs. The second is the generation of waves as a result of interference of the rotor and stator blades. The third mechanism involves a technique of acoustic noise attenuation based on the use of thin porous diaphragms instead of the usual thick absorptive materials. An analysis of the far field of the inlet for the engine at rest is described. Author

N68-32208# Boeing Co., Renton, Wash. Transport Div.
ACOUSTIC ENERGY GENERATION AS A FUNCTION OF TURBOFAN ENGINE DESIGN
Harry Garmanian 21 Jun. 1962 92 p
(D6-9045) CFSTI: HC $3.00/MF $0.65

A program was initiated to cover experimental and analytical investigation of the performance of the variable exhaust geometry in a bypass engine in terms of jet noise attenuation and engine design criteria. The experimental portion of the program, a series of scale-model tests simulating exhaust flow conditions of a coplanar and partially mixed discharge configuration of the JT3D-1 and JT8D-1 turbofan engines, was conducted in the Model Jet Facility. The analytical part of the program was confined to a prediction of the acoustic potential of a fully-mixed discharge configuration of the tested engine. Author

N68-32209# Boeing Co., Renton, Wash. Transport Div.
EXTERIOR SOUND CHARACTERISTICS OF THE 707-320B AIRPLANE
D. L. Bryan 11 Jun. 1962 44 p refs
(T6-2418) CFSTI: $3.00

Acoustics tests were conducted so that the exterior sound characteristics of the Model 320B airplane during various in-flight and ground operations could be determined. The airplane tested was a production Model 320B powered by Pratt and Whitney Model JT3D-3 engines. Sound levels were measured under the flight path of the airplane as it was flying over in level flight. Tests were also conducted during ground-static operation of a single engine at which time sound levels were measured on the ground around the engine. Sound characteristics are presented in the form of sound level tables, frequency-spectrum plots, subjective noise curves, and directivity plots. The maximum sound pressure level at a point on the ground 800 feet below the take-off flight path of the airplane operating at maximum take-off power is estimated to be 109 dB. The corresponding loudness level and perceived noise level would be 117 phons and 120 PNdB, respectively. Author

N68-32210# Boeing Co., Renton, Wash. Transport Div.
MEASUREMENT OF NOISE CONTAINING DISCRETE FREQUENCY COMPONENTS IN THE PRESENCE OF RANDOM NOISE SIGNALS
H. H. Taniguchi 18 Apr. 1962 32 p refs
(D6-8786) CFSTI: $3.00

The measurements of discrete frequency noise and the method of interpreting the data were studied. The study was initiated for the purpose of obtaining a greater understanding of noise measurements made when intense discrete frequency components are present in the noise spectrum. The emphasis is placed on measurements of noise originating from jet engines during ground (static) operations and on measurements taken on the ground during aircraft fly-over (transient) conditions. Special measurement techniques are required for determining the time-average value of a discrete frequency signal. These techniques can be classified as (1) sampling process, whereby the rectified signal is integrated over a fixed time period, and (2) continuous process, whereby the rectified signal is continuously smoothed (with a low-pass filter) and the resultant level displayed on a level-recording device. Author

N68-32211# Boeing Co., Renton, Wash. Transport Div.
PARAMETRIC STUDY OF COMMUNITY NOISE LEVELS FOR VARIOUS ENGINE CYCLES AND WEIGHT FLOWS
Heinz E. Schoernich 20 Feb. 1962 149 p refs
(D6-8147) CFSTI: $3.00

Community noise levels are calculated for airplanes equipped with four power plants, either turbojet or turbofan. A comparison of the perceived noise levels of various weight flows and engine types reveals that the perceived noise level (1) increases with an increase in total weight flow for each engine type, (2) decreases with higher bypass ratios for the same total weight flow, (3) decreases with reduction in power for any engine and any weight flow, and (4) decreases with increase in altitude for any engine and any weight flow. The perceived noise levels presented cover a wide range of total weight flow and engine cycles and should suffice as first approximations for many future airplane configurations. In short, the results of the study can be used to determine the community noise levels for various airplane configurations. Airplane–power plant-matching, aerodynamic, and other studies will yield the altitudes above a community for various airplanes. These altitudes, together with the engine cycle and the engine size, will determine the community noise levels for the airplane to be studied so that the optimum configuration as far as the community noise is concerned can be found. Author

N68-32212# Boeing Co., Renton, Wash. Transport Div.
THE TRANSMISSION OF SOUND INSIDE ABSORBING DUCTS
Heinz E. Schoernich 22 Jan. 1962 80 p refs Previously X65-80645
(D6-8087) CFSTI: $3.00

Theoretical formulas and graphs are derived which can be used to calculate the attenuation in db per foot of duct length. Rectangular, cylindrical, and square ducts with one, two, or four absorbing walls are considered. Since the equations and graphs are cumbersome to use, approximations for the formulas are derived. It is shown that the perimeter for a given area must be as large as possible if maximum attenuation is to be obtained; therefore, a rectangular duct is more favorable than a circular duct. It is also shown that attenuation is increased when duct width is decreased.

Diminishing wall impedance, maximum possible theoretical attenuation, and a method for simplifying the Morse attenuation charts are also discussed. All modifications necessary for the calculation are made so that effective attenuation constants can be calculated for flows over an absorbing liner. Author

N68-32213# Boeing Co., Renton, Wash. Transport Div.
A METHOD OF PREDICTING STATIC TURBOFAN FAR FIELD NOISE
Peh Sun Ku 4 Dec. 1961 64 p refs Previously N64-82461
(D6-7859) CFSTI: $3.00

The jet noise, the fan noise, and the compressor noise were first estimated separately. The resultant spectrum contributed by these three types of noise was obtained by superposition of the respective levels in the appropriate octave bands. As an illustration, the predicted static results for the CJ 805-23 engine indicated good agreement with the measured static results. The maximum deviation from the measured results was 6 db in the octave band levels while the agreement with measured CJ 805-23 data for over-all SPL was ±2 db. Considering the maximum estimated error of measurement of ±2 db, the method is believed to be reliable for qualitative estimating purposes. Author

N68-32214# Boeing Co., Renton, Wash. Transport Div.
COMPARATIVE EVALUATION OF ACOUSTICAL PERFORMANCE OF BASIC AND HUSH KIT VERSIONS OF PRATT AND WHITNEY JT3D-1 TURBOFAN ENGINES
A. M. MirSepasy 29 Sep. 1961 26 p refs
(T6-2111) CFSTI: $3.00

Acoustics tests were conducted so that the acoustical characteristics of the Pratt and Whitney modified JT3D-1 turbofan engine could be evaluated. The test airplane, a 720B, was equipped in turn with (1) Pratt and Whitney Aircraft basic JT3D-1 engines, and (2) Hush Kit modified version of the JT3D-1 engine. The maximum sound pressure level attenuation at a point on the ground 800 feet below the airplane's takeoff flight path, with engines at takeoff power, was 1 db. At the 3400 pound thrust condition, the modified engine afforded attenuations of up to 6 PNdb during the pre-overhead (approach) position of the airplane and at a flight altitude near 400 feet. The Hush Kit modification produced little or no octave band SPL attenuation in the directions of fan discharge noise propagation (approximately 130° from inlet axis), and the normal to the engine axis. Author

N68-32215# Boeing Co., Renton, Wash. Transport Div.
WHINE NOISE IN FAN DUCTS
J. H. Prindle 21 Jul. 1961 48 p Previously X65-80742
(D6-7538) CFSTI: $3.00

The form of the acoustic field developed in a duct by a whining fan is investigated. A basic result is that the modes which will be excited can be predicted by supposing the stator blades are the noise sources. The effects of sound—absorptive walls and of flow in the duct are discussed. Application of the results to the JT8D-1 engine leads to the prediction that lining one foot of the inlet duct should suppress inlet whine at least four or five decibels. Author

N68-32216# Boeing Co., Renton, Wash. Transport Div.
THE DESIGN AND EVALUATION OF AN AERODYNAMIC INLET NOISE SUPPRESSOR
L. Maestrello 12 Dec. 1960 39 p
(D6-5980) CFSTI: $3.00

An inlet model noise suppressor has been designed and successfully tested. The inlet consists mainly of a cylindrical duct with central movable plug. The plug controls the throat area ratio and, as a consequence, induces pressure, density, and velocity jumps across a section of the inlet; this discontinuity suppresses the sound radiated upstream from the compressor. The tests reveal that for an inlet Mach number below 0.5, the noise radiated along the inlet was propagated without attenuation; but as the Mach number increased, the noise decreased; it finally disappeared when the inlet Mach number reached 0.90. The total pressure losses for the scale model varied from 1 to 1.5 inches of mercury, depending on the operating inlet total pressure. Author

N68-32217# Boeing Co., Seattle, Wash.
THE ACOUSTIC NEAR FIELD OF A MODEL AIR JET SIMULATING VERTICAL TAKE-OFF
Stanley Oas 28 Jan. 1958 32 p refs
(D2-2463) CFSTI: $3.00

Detailed measurements were made in the acoustic near field of a supersonic cold air jet exhausting vertically downward onto a ground plane. In the free field, the distribution and power spectrum shape of the model noise field matched very closely that of a 130,000 lb thrust rocket motor, although the power and frequency scale factors did not agree with those based on scaling methods in use. The distortion of the sound field by the ground plane showed the combined effects of sound reflection and the 90° deflection of the jet stream. At close proximity to the ground plane, a 4 db reduction of total radiated acoustic power was measured. The noise spectrum shape differed from the free field shape for all positions of the jet above ground up to and including 32 nozzle diameters. Author

N68-32218# Boeing Co., Seattle, Washington.
PROPAGATION AND MEASUREMENT OF JET NOISE
A. A. Evenson and N. M. Barr 20 Dec. 1957 46 p refs
(D6-2820) CFSTI: $3.00

To obtain consistent data with which to describe the noise fields of jet aircraft, it is shown that very stable conditions are prevalent just after dawn when winds are light and a temperature inversion exists. Three separate tests, conducted under such conditions, gave satisfactory results. Far-field noise measurements are often meaningless unless referred to a standard meteorological condition. Present knowledge does not permit normalization of data acquired under different meteorological conditions. Consistent data may be acquired under a narrow range of meteorological conditions which may be forecast and identified by a professional meteorologist. Author

N68-32219# Douglas Aircraft Co., Inc., Long Beach, Calif. Aircraft Div.
AERODYNAMIC LOSSES CAUSED BY POROUS FIBERMETAL
S. P. Patel May 1967 82 p
(DAC-33722) CFSTI: HC $3.00/MF $0.65

Tests to determine the aerodynamic losses caused by porous fibermetal were conducted in the low speed tunnel. Two fibermetal plates with different porosities (25-Rayl and 10-Rayl material) with 0.75 inch-deep air-cavity backing were tested. For comparison, a smooth solid plate was also tested. When the backing was an air cavity, the momentum–thickness ratios were minimum for zero pressure gradient across the plate. When various types of backings were used in the cavity, the momentum–thickness ratios had the same values as those for the zero pressure gradient. These minimum values were 1.3 for the 25-Rayl fibermetal and 1.6 for the 10-Rayl fibermetal. The high momentum losses for the fibermetals with air-cavity backing are due to the crossflow through the porous surface. Author

N68-32220# Douglas Aircraft Co., Inc., Long Beach, Calif. Aircraft Div.

SONIC FATIGUE DESIGN STUDIES OF NACELLE ACOUSTICAL TREATMENTS. STUDIES CONDUCTED BETWEEN MARCH 1966 AND MARCH 1967
R. L. Frasca May 1967 102 p refs
(DAC-33770) CFSTI: HC$3.00/MF$0.65

A series of sonic fatigue tests on acoustically-treated panel designs were conducted using the Douglas high intensity sound system. These tests were conducted in support of a program directed toward the study of turbofan engine nacelle modifications to minimize fan-compressor noise radiation. The results of these tests aided in evaluating the relative acoustic fatigue strength of the panel designs tested, and served as guidelines for designing similar structure to resist acoustically induced fatigue. Author

N68-32221# Douglas Aircraft Co., Inc., Long Beach, Calif. Structural Mechanics Section.
FLYOVER NOISE DURING TAKEOFF AND LANDING OF THE DC-9-30 AIRCRAFT
E. B. Fish May 1967 19 p
(DAC-33753 CFSTI: $3.00

Data are presented on measured noise levels and measured aerodynamic performance which are necessary to determine takeoff and landing flyover noise levels for airport communities during operation of the DC-9-30. Takeoff noise levels can be determined for full takeoff thrust departures and for departures with a special noise abatement thrust reduction. Noise levels below the landing flight path can be determined for a given landing gross weight for a given distance from touchdown. Author

N68-32222# Douglas Aircraft Co., Inc., Long Beach, Calif. Aircraft Div.
MEASURED FLYOVER NOISE LEVELS OF THE DC-8-62 POWERED BY JT3D-3B ENGINES WITH LONG FAN-DISCHARGE DUCTS
B. B. Adams Mar. 1967 56 p refs
(DAC-33676) CFSTI: HC$3.00/MF$0.65

The results of a program to measure flyover noise of the DC-8-62 powered by JT3D-3B engines with long duct pods are presented. The data are also applicable to the DC-8-63 equipped with the same engines. A description of the testing procedures, data analysis, and the final results are included. With the data presented, one can determine the noise levels on the ground below the aircraft for virtually any thrust condition which may be encountered in either takeoff or landing operations. Included are brief discussions of the test equipment, measurement procedures, and data reduction procedures, as well as a discussion of the techniques used to normalize the measured data points. Author

N68-32223# Douglas Aircraft Co., Inc., Long Beach, Calif. Aircraft Div.
MEASURED FLYOVER NOISE LEVELS OF THE DC-8 POWERED BY JT3D-3B ENGINES WITH SHORT FAN-DISCHARGE DUCTS
B. B. Adams 16 Dec. 1966 81 p refs
(DAC-33523) CFSTI: $3.00

The results of a program to measure the flyover noise of the DC-8 powered by JT3D-3B engines with short duct pods are presented. The data are applicable to the Series 55 and the Series 61 DC-8's. A description of the testing procedures, data analysis, and the final results are included. With the data presented, one can determine the noise levels on the ground below the aircraft for virtually any thrust condition which may be encoundered in either takeoff or landing operations Author

N68-32224# Douglas Aircraft Co., Inc., Long Beach, Calif. Aircraft Div.
MEASURED FLYOVER NOISE LEVELS OF THE DC-8 POWERED BY JJ3D-3B ENGINES WITH SHORT FAN-DISCHARGE DUCTS AND PROTOTYPE FAN-DISCHARGE DUCT SUPPRESSORS
B. B. Adams 16 Dec. 1966 90 p refs
(DAC-33524) CFSTI: $3.00

As a part of the program to reduce airport neighborhood noise levels a flyable prototype noise suppression system was developed for the JT3D-3B turbofan engine with short-duct engine pods. The noise suppression system consists essentially of the installation of sound absorbent surfaces in the fan-discharge ducts of the engine in place of the production surfaces of sheet aluminum. A brief discussion of the amount of noise reduction achieved by the suppressor is included. Author

N68-32225# Douglas Aircraft Co., Inc., Long Beach, Calif. Engineering Div.
FLYOVER NOISE DURING TAKEOFF AND LANDING OF THE DC-8-61 AIRCRAFT
13 Dec. 1966 37 p Revised
(DAC-33379, Rev.) CFSTI: $3.00

Data are presented on the measured noise levels and measured aerodynamic performance necessary to determine noise levels in communities near airports during operation of the aircraft. Because there are very few differences between the −55 and −61 DC-8s, all of the data presented will be applicable to both versions of the aircraft unless indicated. The drag of the DC-8-61 on the approach configuration is significantly less than that of the DC-8-55 as measured during flight. Thus, despite an increase in landing gross weight, the approach noise of the DC-8-61 will be about the same as for the DC-8-55 due to the lower engine thrust required to follow a three degree glide slope. Author

N68-32226# Douglas Aircraft Co., Inc., Long Beach, Calif.
A METHOD FOR THE DETERMINATION OF THE NOISE RADIATED FROM TURBOJET AIRCRAFT DURING TAKEOFF
Michel Kobrynski 23 Nov. 1966 72 p refs Transl. into ENGLISH from ONERA Tech. Note No. 81, 1965
(DAC-33481) CFSTI: HC$3.00/MF$0.65

A general calculation method is proposed which is applicable to airplanes on a test stand, during the takeoff roll and in subsonic flight. The calculation method rests on Lighthill's law of the variation of the acoustic power with SV_j^8 and involves the amplification of the sound intensity through the convection factor (for either stationary or moving jets) and a reduction factor given by an aerodynamic effect and the Doppler attenuation effect. An important result is the evidence of an aerodynamic effect on the turbulence of the jet, a function of $(1 + V_e/V_j)^2$ which causes a change to the emitted frequencies and a reduction of the sound intensity by the factor $(1 + M \cos \Theta_M)^4$ Author

N68-32227# Douglas Aircraft Co., Inc., Long Beach, Calif. Aircraft Div.
METHOD OF CALCULATING NOISE PRODUCED BY JET AIRPLANES DURING TAKEOFF
Michel Kobrynski 6 Sep. 1966 26 p refs Transl. into ENGLISH from ONERA Tech. Paper No. 249 (France), 1965 and La Rech. Aerospatiale (France), No. 105, Mar./Apr. 1965
(DAC-33359) CFSTI: HC$3.00/MF$0.65

A calculation method based on the sound emission laws for stationary and flying jets and on the directional characteristics of the noise has been established. Relations between the noise levels and the characteristics of the jet are defined and verified by a large number of experimental data. This work leads to a unique calculation method for airplanes in flight and on the ground. The application of the method is simplified with the use of design

charts. The method is applicable for future airplanes, now in the design stage, whose engines have predicted jet exhaust velocities exceeding those of present-day engines. The investigation of a generalized spectrum, common to all cases, clearly shows the effect of entrainment by the jet in flight on the emitted frequencies. Author

N68-32228# Douglas Aircraft Co., Inc., Long Beach, Calif. Acoustics Section.

FLYOVER NOISE DURING TAKE-OFF AND LANDING OF THE SERIES 50 DC-8 WITH P and WA JT30-1 TURBOFAN ENGINES

A. L. Mc Pike and A. H. Marsh 20 Jul. 1961 34 p refs
(LB-30637) CFSTI: $3.00

The jet exhaust noise of the JT3D-1 engine is considerably lower than that of an equivalent turbojet engine; however, the pure tone whine of the JT3D-1 is greater in magnitude than that of the turbojet and has different directional characteristics. A series of tests were conducted to determine the noise levels under the flight path during takeoff and landing operations of the DC-8 powered by JT3D-1 engines without the Pratt and Whitney Hush Kits. The noise levels as determined by these tests are presented to show what noise levels can be expected in airport communities during takeoff and landing operations. Author

N68-32229# Douglas Aircraft Co., Inc., Long Beach, Calif. Aircraft Div.

FLY-OVER NOISE DURING TAKE OFF OF THE DC-8 WITH JT3C-6 ENGINES

A. L. Mc Pike 22 Mar. 1961 70 p refs Revised
(SM-23641, Rev.) CFSTI: HC $3.00/MF $0.65

A series of tests were run to determine the noise levels under the flight path of the DC-8 during takeoff. The purpose was to show the perceived noise level which can be expected from the DC-8 under various operating conditions during takeoff and to explain how acceptable noise levels can be achieved by the selection of suitable runways and the use of engine power reductions. The data presented show that runways with adequate distance from start of takeoff roll to heavily populated areas must be used and appropriate engine power reductions during takeoff must be considered in relation to airplane loading if the 112 PNdB requirement of the Port of New York Authority is to be satisfied by the DC-8. Author

N68-32230# Douglas Aircraft Co., Inc., Long Beach, Calif. Aircraft Div.

FLY-OVER NOISE DURING TAKE OFF OF THE DC-8 WITH JT4A-9 ENGINES

A. L. Mc Pike 17 Dec. 1959 29 p refs
(SM-23787) CFSTI: $3.00

A series of tests was conducted to determine the noise levels during takeoff under the flight path of the DC-8 with JT4A-9 engines and Daisy-Ejector suppressors. The purpose was to show the perceived noise level which can be expected from the DC-8 under various operating conditions during takeoff, and to explain how acceptable noise levels can be achieved by the selection of suitable runways and the use of engine power reductions. The data presented show that runways with adequate distance from start of takeoff roll to heavily populated areas must be used and appropriate engine power reductions during takeoff must be considered in relation to airplane loading if the 112 PNdB requirement of the Port of New York Authority is to be satisfied by the DC-8. Author

N68-32231# Douglas Aircraft Co., Inc., Long Beach, Calif. Aircraft Div.

SIMILARITY CONSIDERATIONS OF NOISE PRODUCTION FROM TURBULENT JETS, BOTH STATIC AND MOVING

Alan Powell 1 Jul. 1958 23 p refs Previously N63-84105
(SM-23246) CFSTI: $3.00

Once a suitable fundamental equation is chosen, similarity arguments may be applied to the question of noise source distribution in turbulent jets in regions adjacent to the potential cone and far downstream. Certain modifications to the analysis are made in the light of certain experimental data. Similarity analyses then yield the following conclusions. The intensity of source distribution along the jet seems to be nearly constant, perhaps rising slightly, from the exit to some point just beyond the end of the potential cone, after which it falls off rapidly. The high frequency part of the spectrum, arising from regions adjacent to the potential cone, depends on the jet exit velocity raised to the ninth power, or a little greater, and upon f-2, or somewhat steeper. The assumption that the downstream region of the jet is responsible for the low frequency part of the spectrum results in a spectrum level depending on about the fifth power of the exit velocity with a slope of f^2. These results are in moderate agreement with such experimental data as are available. Author

N68-32232# Douglas Aircraft Co., Inc., Long Beach, Calif. Aircraft Div.

GENERALIZED PERFORMANCE OF CYLINDRICAL AND CONICAL AIRCRAFT EJECTORS

R. W. Mc Jones, J. A. Sain, and J. R. Flores 28 Dec. 1956 42 p refs
(LB-25320) CFSTI: $3.00

The available NACA theoretical and experimental studies of cylindrical and conical ejectors have been generalized and combined into working charts for use in estimating the pumping and thrust characteristics of a wide range of aircraft jet-exhaust ejectors. In general, theoretical treatments are limited to ejectors with cylindrical shrouds; however, both cylindrical and conical ejector performance may be correlated against the parameters suggested by cylindrical theory, and the minor variations in performance may be handled by empirical corrections. The most important difference between cylindrical and conical ejectors is a serious thrust loss of the latter type under certain conditions. Author

N68-32233# Douglas Aircraft Co., Inc., Santa Monica, Calif.

THE PUMPING CHARACTERISTICS OF LONG MIXING SECTION JET PUMPS

N. L. Fox 5 Sep. 1952 43 p refs Revised
(SM-14385, Rev.) CFSTI: $3.00

Two theoretical analyses are presented for the pumping characteristics of a jet pump, both of which assume complete mixing in a constant area mixing section which is not choked, and neglected friction. The first analysis, which neglects compressibility, yields an equation sufficiently simple for engineering use. The second analysis, which considers compressibility, leads to a better understanding of the system, but is tedious for calculation. Correction factors, based on experimental data and supported by the compressible analysis, are applied to the incompressible analysis to yield results sufficiently accurate for most engineering use. Author